New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB)

Standard Operating Procedure (SOP) for

PHYSICAL HABITAT MEASUREMENTS

Approval Signatures

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1.0 Purpose and Scope

The purpose of this procedure is to describe the process for measuring the physical habitat attributes and geomorphic characteristics relating to the dimension, pattern, and profile of wadeable streams. This procedure can be applied to "larger rivers" however exemptions do apply, for more information reference the SWQB *Comprehensive Assessment Listing Methodology (CALM)*, Appendix G (NMED/SWQB 2025 or most recent). Measurements include a reach wide pebble count, thalweg profile, large woody debris estimate, cross sectional surveys, bankfull cross-section with streamflow, percent canopy cover, and slope. If biological collections such as periphyton, benthic macroinvertebrates, or fish are needed, refer to appropriate SOP for data collection methods. All SWQB SOPs can be found at https://www.env.nm.gov/surface-water-quality/sop/.

To understand the current condition and predict the future condition of a flowing waterbody, it is necessary to determine certain characteristics relating to dimension, pattern, and profile. The hydraulic geometry (also known as river morphology or geomorphology) of a stream is important when investigating sediment transport and relative channel stability. According to Rosgen (1996), "For a stream to be stable it must be able to consistently transport its sediment load, both in size and type, associated with local deposition and scour." Similarly, channel characterization and percent canopy cover are important because they significantly impact water temperature and will influence whether a stream will meet the temperature standard for its aquatic life use.

SWQB's habitat and geomorphology data may be used for but not limited to the following activities:

- assess the general narrative standards for sedimentation/siltation, plant nutrients, and biological integrity using the SWQB assessment protocol (NMED/SWQB 2025 or most recent);
- evaluate quality of habitat and channel stability, aid in identification of stressors in impaired reaches, and provide data for TMDL development;
- provide baseline data to refine water quality standards, classify waterbodies, and define reference conditions;
- monitor differences above and below a perturbation, point source, best management practice (BMP), and/or non-point source disturbance; and
- review plans or proposals submitted for in-stream construction activity (CWA §404/§401 certification).

2.0 Personnel Responsibilities

The Quality Assurance Officer (QAO) is involved in the development and revision of this SOP to ensure the SOP meets the requirements of the most current SWQB's Quality Assurance Project Plan. The QAO; the Monitoring, Assessment, and Standards Section (MASS) Program Manager; and the SWQB subject matter experts (e.g., the MASS Monitoring Team Lead and field staff scientists) will determine if any revisions to this SOP are needed at a minimum of every two (2) years in accordance with SOP 1.1 for the Creation and Maintenance of SOPs (https://www.env.nm.gov/surface-water-quality/sop/). Pending the review and approval of the document, the QAO will ensure the SOP is accessible through the SWQB's website.

Personnel who conduct physical habitat sampling and related data validation and verification activities or who supervise those who do must be familiar with this SOP.

Technical staff should have experience collecting geomorphic, hydrological, and biological data in New Mexico streams. All new Monitoring Team employees will receive training and perform each of the field measurements described in this SOP under the supervision of a senior technical staff member at least once before being permitted to make these measurements without a senior technical staff member present.

3.0 Background and Precautions

This SOP is designed to be used in wadeable perennial streams and is not appropriate for generating sedimentation/siltation data for assessment of large river systems, intermittent or ephemeral streams, lakes and reservoirs, beaver ponds or backwater features, or wetlands. If a site is dry or has isolated pools the visit will be recorded as such.

If the habitat or biological sampling is not done at an established water quality station, then the location and distance from the nearest established station within the same AU will be documented on the appropriate field sheets. If the work is done more than 1 kilometer from the water quality station, then a new station will be established.

If biological monitoring such as fish, benthic macroinvertebrates or periphyton are scheduled to be collected at a particular site, both physical habitat and biological field measurements will be collected during the biomonitoring index period and **at least six weeks after a scouring flow event**. (Biggs & Kilroy 2000). The occurrence of recent scouring of the course substrate can be determined with an evidence-based approach (see Physical Habitat Field Work Cover Sheet). Note recent depositional features, incisions, downcuts, wrack lines at or above assessed bankfull, absence of periphyton growth, folded in-channel vegetation, folded vegetation on the floodplain, and translocation of the current year leaf litter on active floodplain. If nearby gage data are available, note any high flows with gage height 3x the previous week average. The occurrence of four or more of these factors is considered a scour event. Attempt to estimate the timing of the event with gage data or new vegetation emergence. If timing cannot be determined, assume that the event occurred the previous day and plan resampling accordingly.

If concurrent biological monitoring is planned, SWQB’s Physical Habitat surveys are completed during stable low flow conditions, between August 15 and November 15 (preferably before deciduous tree leaves have dropped), because this is SWQB’s historic biomonitoring index period. If no biological monitoring is planned or needed at a particular site, physical habitat surveys may be conducted during the above-described index period, or during baseflow conditions post snowmelt runoff and prior to the monsoon season (generally mid-May through early-July depending on location and weather patterns).

3.1 Sampling During or After Rain Event

Do not sample during high flow rainstorm events. It is often unsafe to be in the water during such times and biological conditions during and after high flows are often quite different from those during baseflows. Some compromise is necessary regarding whether to sample a given stream because of storm events. This decision is based on the following guidelines to help determine the influence of rain events:

1. If the stream is running at or above bankfull flow or the water seems much more turbid than typical for the class of stream do not sample that day.
2. Do not sample a stream if it is unsafe to wade in the stream reach.
3. Keep an eye on the weather reports and rainfall patterns. Do not sample a stream during periods of prolonged heavy rains.
4. If the stream seems to be close to normal summer flows and does not seem to be significantly influenced by recent storm events, proceed with sampling even if it has recently rained or is raining, and document site conditions on the field form.

If you decide a site is significantly influenced by a storm event, do not sample the site that day and document the site conditions on the field forms so the stream can be rescheduled for another visit.

3.2 Rule of 10

Wading across a stream bed can be very dangerous depending on flow and substrate conditions. Do not attempt to wade into a stream if the depth (in ft) multiplied by the velocity (in ft/s) equals or exceeds 10 square feet per second (ft^2/s). For example, a stream that is 2 ft deep, and has velocities of 5 ft/s or more, should be considered too dangerous to wade. If you unknowingly start to take measurements and discover part of the way across that you are/will violate the rule of ten, return to the nearest bank and note “too fast/deep to measure” on the field form. Refer to SWQB’s Job Hazard Analysis (JHA) for further safety precautions when conducting field work.

3.3 Streambed Concerns and Obstacles

Some channels have quicksand-like areas, deep holes, sharp rocks, excessive fallen logs, etc., that can lead to foot entrapment, injury, or falls. A wading rod, surveyor’s rod, ski pole, or stick can be used for stabilization and to probe the streambed when conditions are uncertain. Staff should use best professional judgment to assess risks involved with data collection. Refer to SWQB’s JHA for further safety precautions when conducting field work.

4.0 Definitions

For common definitions and acronyms not defined in this SOP, refer to the most up to date SWQB Quality Management Plan for Environmental Information Operations (https://www.env.nm.gov/surface-water-quality/qaqc/).

The following definitions may be utilized in any aspect of physical habitat monitoring, especially in field notes, documentation of transect type, and descriptions of habitat diversity:

Bankfull Flow - equivalent to the “effective discharge”; the flow which transports the greatest volume of sediment over time. Evidence from many streams suggests that these bankfull flows are frequent, moderately sized, and represent the channel forming or maintenance flows.

Bankfull Height (or Stage) – the point of incipient flooding or the elevation where flows overtop the active channel and spread across an adjacent active floodplain as constructed by the present stream in the present climate, and frequently inundated with a typical return interval of 1 to 2 years and represent the channel forming or maintenance flow (Dunne and Leopold, 1978). Bankfull Height measurements are taken by measuring the distance from the water's surface to the bankfull tagline, leveled surveyor's rod or tape.

Left Bank – the bank on the left as the observer faces downstream (in the direction of flow).

Right Bank – the bank on the right as the observer faces downstream (in the direction of flow).

Bankfull Width – the horizontal distance between the bankfull height on the left and right bank.

Dry Channel - no water in the channel.

Edge of Water – the point on the left and right bank, denoted as LEW and REW respectively, where the water meets the bank.

Interval Length - the distance between thalweg profile measurements determined by dividing Total Reach Length by 160

Large Woody Debris –woody material with a small end diameter of at least 10 cm (4 in.) and a length of at least 1.5 m (5 ft).

Off-Channel Areas – side-channels, sloughs, backwaters, and alcoves that are separated from the main channel

Percent Canopy Cover – the amount of riparian vegetation intercepting solar radiation may be quantified as the average percent canopy density.

Pools – still water, low velocity, smooth, glassy surface, usually deep compared to other parts of the channel

Run or Glide – water moving slowly, with a smooth, unbroken surface. Relatively shallow and low turbulence

Riffle – turbulent, shallow flow; Water moving, with small ripples, waves and eddies -- waves not breaking, surface tension not (or barely) broken. Sound: "babbling", "gurgling"

Total Reach Length – the total distance from transect A to transect E based on average wetted width.

- if Average Wetted Width <= 4.0 m, Total Reach Length = 160 m
- if Average Wetted Width > 4.0 m, Total Reach Length = Average Wetted Width x 40

Thalweg –the flow path of the deepest water joining the lowest points in a stream channel. The path followed by most of the water in a stream.

Wetted Width – the width of the stream bed covered by water perpendicular to flow (i.e., distance between LEW and REW).

5.0 Equipment and Tools

- Field forms printed on rain proof paper or capabilities for use of Electronic Version
- Bank pins
- Measuring tape (with both standard and metric units) – minimum 200 meter
- Metric ruler or Measuring Caliper
- 2 telescoping surveyor's rods (with both metric and imperial scale, 7.5 m extended)
- Small level or bubble level
- Densiometer modified with taped "V"
- Range Finder with Slope function (e.g., Nikon Forestry Pro II Laser Range Finder)
- Clinometer
- GPS unit or cell phone capable of determining lat/long
- 5 – 10 flags to mark transects
- Recommended 1 or 2 fisherman's vest with lots of pockets and snap fittings (used at least by person conducting the in-channel measurements to hold the various measurement equipment (densiometer, clinometer, etc.); useful for both team members involved with physical habitat characterization)
- Chest waders; hip waders can be used in shallower streams
- Clipboards
- Soft lead (#2) pencils
- SOP and/or quick reference guides for physical habitat printed on Write in the Rain® paper
- Camera (e.g., phone or digital)

6.0 Step-by-step Process Description

6.1 Office Procedures (Prior to field work)

For planning and scheduling purposes, review field sampling plan to confirm planned physical habitat sampling locations and needs. Before conducting field work, view satellite imagery using the online SWQB mapping tool or another online imagery application. Ensure that the reach area is representative of the AU being characterized. If necessary, contact landowners to gain access to the area.

Table 1. Survey Layout

Physical Habitat Components	Layout Location
Slope	Entire Reach (Transect E to Transect A)
Cross Sectional Profiles	Lettered Transects A-E
Thalweg Profile	Thalweg Profile Stations (160 total)
LWD Estimate	Between Lettered Transects
Percent Canopy Cover	Lettered Transects A-E
Pebble Count	All Transects[1]
Bankfull Cross Section with Flow	One Lettered Transect[2]

[1] All Transects includes lettered and intermediate transects (i.e., entire reach).

[2] The preferred location is at Transect C, but the location can be moved as necessary to find an area that is straight with perpendicular flow at the cross section. Conduct at one transect only.

6.2 Reach Selection and Layout

6.2.1 Reach Selection

Reach selection is a critical decision that can greatly influence the outcome of subsequent field procedures. Before selecting a location for the survey, note the character of the stream while driving to the site, and conduct a site walk to ensure that the reach is representative of the AU being characterized. In the field prior to laying out the transects, take time to walk upstream and downstream of the monitoring station to observe the occurrence of riffle-run-pool sequences, riparian and bank characteristics, and isolated features such as culverts or other human disturbances. Do not include culverts, irrigation diversions, or related channel/bank human-made manipulations, within the reach that have altered flow or cross-sectional dimensions of the sample reach. Isolated human disturbances can be included if they are present throughout the AU. Do not include human made channels/features and recent restoration unless they make up the entire AU. Keep these factors in mind to ensure a representative proportion of geomorphic and disturbance features are in the selected reach.

While conducting the site walk, measure the wetted width of the stream in at least five locations. The average wetted width is used to determine the length of the total reach. Data collection must not be made at one point without first walking a 250-meter reach in the vicinity of the monitoring station.

If the channel is covered by greater than 50% rooted vegetation and dominated by fine substrate, record this on the field sheet, document with photos and do not conduct any surveys/data collection. Abundant growth of aquatic vegetation can be indicative of riverine wetland systems which are associated with free-flowing bodies of water. “Macrophyte” is a general term that applies to many types of aquatic vegetation. Emergent macrophytes grow in depths of water generally less than a meter and are typically rooted in the sediment with a portion of the plant in the water and part extending into the air, whereas submerged macrophytes grow completely underwater. Common emergent macrophytes include reeds (*Phragmites spp*.), bulrushes (*Scirpus spp.*) and cattails (*Typha spp*.).

6.2.2 Reach Layout

Calculate the average wetted width from the wetted widths measured during reach selection to determine the length of the total reach. For streams with an average wetted width less than or equal to 4.0 m, a representative reach is 160 meters. For streams with widths greater than 4.0 m, the length of the total reach is 40 times the average wetted width. The reach length is measured along the stream channel following the sinuous path of flow. When feasible, the measuring tape should be laid out along the sinuous flow path for the entire survey reach. Surveys are grouped into activities and are performed at specific locations along the total reach (Figure 1). Since the Slope is typically the first activity to be performed, the transects for the other measurements (e.g., channel dimensions, streamflow, etc.) can be established as slope is being conducted (Table 2). Record GPS location of Transect A and Transect E on Physical Habitat **Field Form Cover Sheet.**

Table 2. Location and intervals of transects for surveys activities (see Figure 1 for Reach Layout)

Reach Layout	**SMALL STREAMS** (Average wetted width less than or equal to 4.0 m) Total Reach Length = 160 m	**LARGE STREAMS** (Average wetted width greater than 4.0 m) Total Reach Length = Avg Wetted Width x 40 m
Total Reach Length	Example: Average wetted width = 3 m Total Reach Length = 160 m	Example: Average wetted width = 6 m Total Reach Length = 240 m
Transect (Flow, Cross Section, Canopy Cover)	**5 Lettered Transects spaced 40 meters apart** Example: Average wetted width = 3 m Distance between transects = 40 m* Transect A (1st transect) = at 0 meters Transect E (5th transect) = at 160 meters	**5 Lettered Transects at 10X average wetted width apart** Example: Average wetted width = 6 m Distance between transects = 60 m* Transect A (1st transect) = at 0 meters Transect E (5th transect) = at 240 meters
Intermediate Transect (Pebble Count)	**21 Contiguous Transects spaced 8 meters apart (i.e., entire reach layout)** Example: Average wetted width = 3 m Distance between intermediate transects = 8 m	**21 Contiguous Transects at 2X average wetted width (i.e., entire reach layout)** Example: Average wetted width = 6 m Distance between intermediate transects = 12 m
Thalweg Profile Stations	**Measure thalweg depth every 1.0 meter (160 total measurements)** Example: Average wetted width = 3 m Interval Length (distance between thalweg depth profile measurements) = 1 m Total measurements = 160	**Measure thalweg depth at intervals equal to Total Reach Length divided by 160 (160 total measurements)** Example: Average wetted width = 6 m Interval Length (distance between thalweg depth profile measurements) = 1.5 m Total measurements = 160

* It is helpful to use flagging tape to indicate the halfway point between transects to orient the sampler.

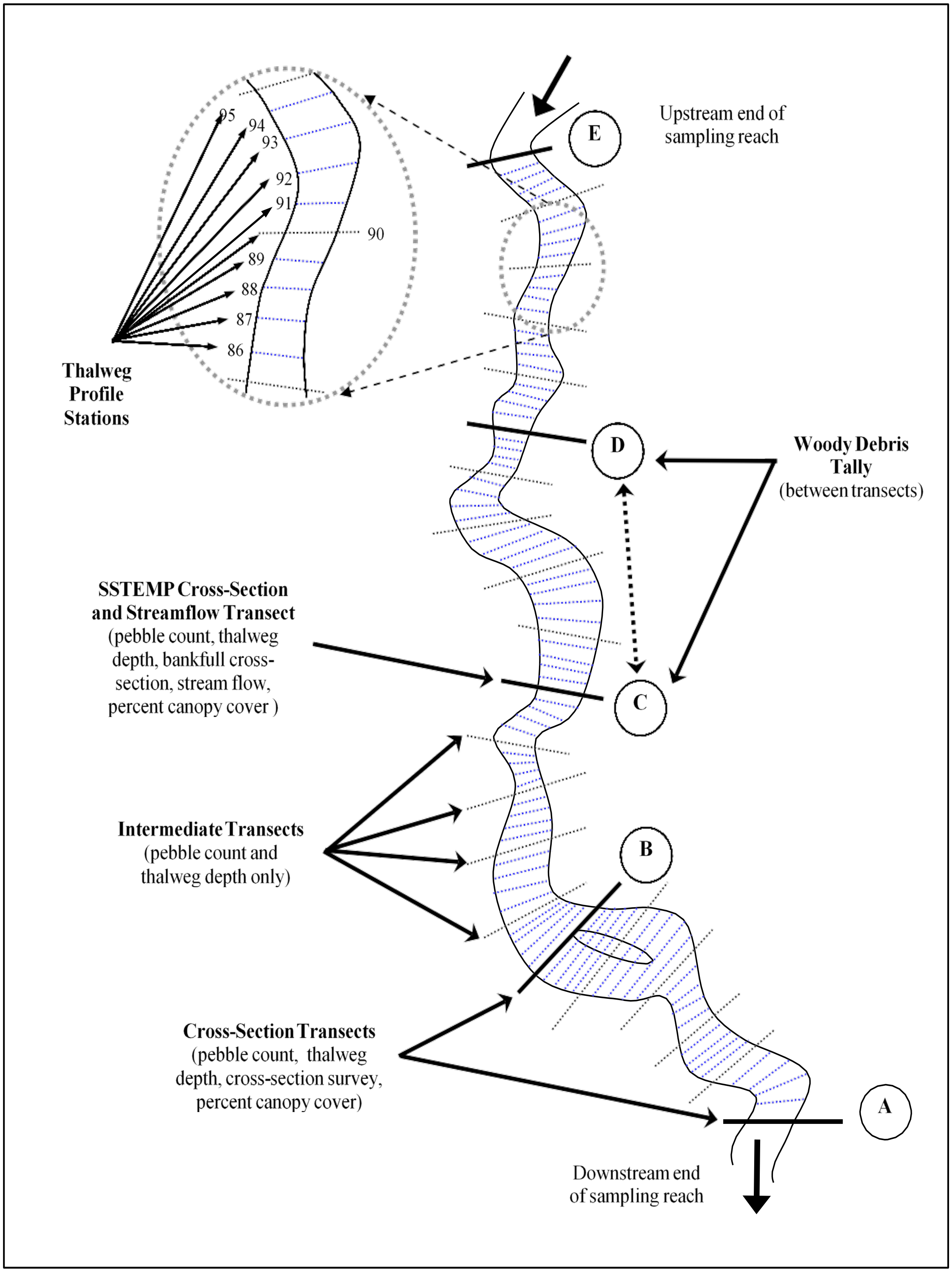

Figure 1. Reach layout for physical habitat measurements

6.3 Logistics and Workflow

The seven components of physical habitat measurements are organized into grouped survey activities:

1. Slope (Section 6.3.1)
2. Cross Sectional Profile, Thalweg Profile and Large Woody Debris Estimate (Section 6.3.2)
3. Pebble Count (Section 6.3.3)
4. Bankfull Cross-Section and Stream Flow (Section 6.3.4)
5. Percent Canopy Cover (Section 6.3.5)

All survey activities should be performed concurrently as data from these activities are used in conjunction with one another for assessment calculations (i.e., determination of Relative Bed Stability) and temporal variation must be limited. Once a particular activity has been started by an observer, the initial observer is required to complete the activity in its entirety for that monitoring station. For instance, if an observer begins the pebble count activity, the same observer must complete the entire pebble count at that particular monitoring station. Observers may change from one particular activity to another at each monitoring station (e.g., one observer may collect data for the pebble count, and a different observer may collect data for percent canopy cover for the same monitoring site).

6.3.1 Slope

Slope is typically measured by two people, one using a range finder (with slope capabilities), clinometer, or water tube (i.e., roofers level) and the other holding the survey rod. The intent is to measure the surface water slope, which may not necessarily be the same as the bottom or valley slope. Please see procedure below **for collecting Slope using a range finder, clinometer, or hand level. Slope is recorded on field sheets as positive number unless slope is 0%.**

Procedure for Reading Slope with a Range Finder (with slope capabilities)

The SWQB is currently utilizing the Nikon Forestry Pro II Laser Range Finder, which reads slope in degrees, which will be transformed to percent slope on the Physical Habitat field sheet utilizing the following equation:

$$\tan(s) * 100$$

s = Slope in degrees

The procedure generally begins at Transect E after the site walk and reach length has been determined. See Reach Layout Section of this SOP for more information.

Mark the slope collection method used on the Slope Field Form. The entire stream path must be measured by capturing all the sinuosity when collecting Slope. **Do not measure over land or cut across meander bends.** If channel meanders prevent sighting entire length between transects intervals, break measurements into smaller segments that do not cut across land or bends.

1. Measure the eye level of the individual using the range finder and mark eye level height on survey rod. This is the height (point on the rod) that will be used to determine slope.

2. The team member with range finder will stay at beginning transect (typically transect E) location and must record slope measurements and distance on field sheet throughout the entire procedure.

   Note: The person utilizing the range finder will be responsible for measuring and recording the distances between transects (or half-transects, measuring points) on field sheet and will ensure staff with the surveyor's rod are at correct distance.

3. Slope measurements must be taken standing at the edge of the water (i.e., water level). Individual(s) using range finder will sight (typically shoot downstream) distance and slope to their marked eye level on the surveyor's rod downstream.

4. The team member(s) responsible for survey rod will walk downstream to the half-transect points (e.g., D.5) for the collection of slope measurements. Typically, in 20 meters transects for a reach of 160 meters or **the furthest visible point** (if 20 meters is **not** achievable). At each 20 meter transect the stream will be marked with flagging indicating half transects and Transects A-E as applicable.

5. Team member(s) responsible for surveyor rod must hold rod vertically (use bubble level to ensure rod is vertical) with the base at the water surface. If no suitable location is available at the stream's edge of water, position the rod on a mid-channel rock or other surface at the same level as the water surface.

6. Team member utilizing range finder will take measurements of slope and distance by sighting range finder to marked eye level on survey rod being held downstream. Staff utilizing the range finder will report distance in meters and slope measurement in degrees on field sheet.

7. Proceed to the next downstream, line-of-sight location and repeat Steps 2 through 6 until the entire total reach has been "sighted".

Procedure for Reading Percent Slope on a Clinometer or Hand Level

Clinometers and hand levels may read both percent slope and degrees of the slope angle; be careful to read and record percent slope. Verify this by comparing the two scales. Percent slope is always a higher number than degrees of slope angle (e.g., 100% slope = 45° angle). For slopes greater than 2%, read the percent slope to the nearest 0.5%. For slopes less than 2%, read to the nearest 0.25%. If the reading is 0% but the water is moving, record the slope as 0.1%. If the reading is 0% but the water is not moving, record the slope as 0%. The procedure for measuring slope using a clinometer or hand level is presented below.

This procedure generally begins at Transect E with slope collected moving downstream but may also be used starting at Transect A and moving upstream. Mark the method used for the collection of slope measurements on the Slope Field Form.

1. Measure the eye level of the person using the clinometer or hand level on the survey rod. This is the height (point on the rod) that will be used to determine slopes.

2. Stand at the edge of water at the beginning cross-section transect. Determine how far you can see the center of the channel without sighting across land.

3. Have one person take the surveyor's rod downstream to the furthest point where you can stand at the edge of water at the upstream location. Measure the distance between the upstream and downstream locations using a measuring tape or laser range finder and record this distance on the field form. Report distance in meters. Measure the entire stream path capturing all the sinuosity. Do not measure over land and cut across meander bends. While also marking transects (A-E) and haft transects.

4. Have the downstream person hold the surveyor's rod vertical (use bubble level to ensure rod is vertical) with the base at the same level as the water surface. If no suitable location is available at the stream margin, position the rod on a mid-channel rock or other surface at the same level as the water surface.

5. At the other location, have the person stand at water level.

6. With the clinometer, sight back upstream or downstream to the marked height on the surveyor's rod at the downstream location. Record % slope.

   For the hand level, sight downstream (or upstream) to the surveyor's rod and indicate to the surveyor (person holding survey rod) where the level mark is on the level. Take that height and subtract the height in step 1 to get your rise. Divide your change in height by your distance to get your percent slope.

7. Proceed to the next downstream, line-of-sight location and repeat Steps 3 through 6 until the entire total reach has been "sighted".

6.3.2 Cross Sectional Profile, Thalweg Profile and Large Woody Debris Estimate

CROSS SECTIONAL PROFILES

This process is conducted at lettered transects A – E. Data are recorded in the **Cross Sectional (XSEC) Profiles** section of the **Cross Sectional Profiles, Thalweg Profile, and Large Woody Debris Field Form**. Features measured include wetted width, depth of water, bankfull width, and bankfull height.

Determining Bankfull Cross Sectional Area:
There is no single, absolute, and definitive line for bankfull stage. Instead, the strategy is to build

a case for identification of bankfull based on physical evidence at the site[1]. The best evidence of bankfull stage is a series of features that are depositional, containing similar substrate and vegetation components, and lying at a consistent elevation, such as:

- topographic breaks in slope
- tops of point bars
- changes in vegetation
- changes in size of bank or bar materials
- evidence of an inundation feature such as small benches
- the presence of a floodplain
- exposed root hairs below an intact soil layer indicating exposure to erosive flow bank undercuts

If the stream or river has incised it may have abandoned the floodplain, which will make the former floodplain a low terrace. It is critical to distinguish the active floodplain from low terraces in the identification of bankfull stage. Remember that in many incised channels within New Mexico the most evident flat valley surface may be an abandoned terrace. Use common sense and local knowledge (including but not limited to regional curves[2]) in deciding whether it is realistic that a particular elevation is inundated nearly every year. Where channels have incised and evolved to the point where a new depositional feature is redeveloping as an active floodplain, the determination of bankfull is less problematic and unambiguous. In other highly incised channels where bank erosion and bed scour are prominent, lack of consistent and unambiguous bankfull indicators may preclude any reliable determination of bankfull dimensions. In these situations, use best professional judgment in estimating bankfull dimensions and note the lack of consistent and reliable indicators on the field sheet.

1. **Bankfull Width and Height Measurements:** Starting at the bottom of the reach (Transect A), lay a surveyor's rod or stretch a measuring tape (tag line) tight across the stream perpendicular to stream flow. Surveyors rod or measuring tape should be placed so that the "zero" end is at left bankfull, as viewed when looking downstream. If a measuring tape is used, measuring tape needs to be secured with bank pins on each side of reach and measuring tape should be pulled taut to minimize error due to sagging. Adjust the rod or measuring tape, as needed, to ensure that rod or tape is adjacent to ground level at left and right bankfull points and level. Determine bankfull width value on right bank at bankfull stage height. After determining bankfull width, measure bankfull height with meter stick or survey as the distance from the edge of water surface water to the bankfull level indicator (i.e., tag line). The bankfull height should be the same at both the left and right bank but it will not necessarily be the same at every cross sectional profile A-E. For example, a cross sectional profile taken at a cross section with a wider bankfull width would be expected to have a smaller bankfull height than a profile taken at a more incised

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[1] https://www.fs.usda.gov/rm/pubs_rm/rm_gtr245.pdf; https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=1256; https://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/413.pdf

[2] https://efotg.sc.egov.usda.gov/references/public/AZ/Arid_SW_Report_Regional_Curves.pdf

cross section with a narrower bankfull width.

Record the bankfull width in meter (m) and bankfull height in centimeters (cm) in the TRANSECT A section.

2. **Additional Cross Sectional Profile Measurements:** After recording bankfull width and height, measure additional **channel dimensions**. The first measuring point will be at left edge of water (Left Bank), then 25% of wetted width (LCtr), 50% of wetted width (Ctr), 75% of wetted width (RCtr) and 100% of wetted width (right edge of water/Right Bank).

   a) Record values from tagline that correspond to measuring point in ***Tag Line*** fields in meters (m) in the fields labeled Left Bank, LCtr, Ctr, RCtr, and Right Bank.

   b) Place your meter stick or survey rod at the measuring point identified above to measure and record the corresponding **depth of water** in centimeters (cm).

THALWEG (LONGITUDINAL) PROFILE

The thalweg profile is a longitudinal survey of maximum flow path depth (deepest water joining the lowest points in a stream channel) at 160 evenly spaced intervals over the length of the total reach. The Thalweg Profile Procedure (below) describes in detail how to determine the distance between thalweg measurements.

The procedure for obtaining thalweg profile measurements is modified from Peck et al. (2006)**.** Record data on the **Thalweg Depth** section of the **Cross Section, Thalweg Profile, and Large Woody Debris Field Form**. A survey rod, metric ruler, or calibrated rod/pole is used to make the required depth measurements at each interval and to measure the distance between stations (as needed) as you proceed upstream. The first thalweg measurement is typically taken at the most downstream station in the total reach (*Transect A*) but can be started at either end of the total reach (Transect A or Transect E).

Thalweg Profile Procedure
One person begins at one end of total reach and walks carrying a survey rod taking depth measurements. A second person records data on Field Sheets (Electronic or hard copy).

1. Determine the interval length between thalweg measurements based on the wetted width used to determine the length of the total reach (see Table 2).
   - For widths less than or equal to 4.0m, measure thalweg depth every 1.0m (160 total measurements).
   - For widths greater than 4.0m, divide the reach length by 160 to determine thalweg depth intervals (160 total depth measurements).

2. Complete the header information on the field form. Record the interval distance determined in Step 1 in the *Interval Length* field on the **Cross Section, Thalweg Profile, and**

Large Woody Debris Field Form.

3. Begin at the downstream end (*Transect A*) of the reach. Locate the flow path that connects the deepest points within the channel (the thalweg). This may not always be found at mid-channel and may not always be a point within the greatest flow path in every channel cross-section. Measure thalweg depth to the nearest centimeter and record it in the *Thalweg Depth* field on the field form. Read the depth on the **side** of the ruler, rod, or pole to avoid inaccuracies due to the wave formed by the rod in moving water. Multiple measurements should be taken by each observer at each thalweg profile station to ensure measurements were taken at the maximum flow path depth (deepest water joining the lowest points in a stream channel).

   NOTE: For streams with interrupted flow, where no water is in the channel at the station, record zeros for depth.

   NOTE: It is critical to obtain thalweg depths at **all** stations. *If the thalweg is too deep to measure while wading*, stand in shallower water and extend the rod or pole at an angle to reach the thalweg. Determine the rod angle by resting a clinometer on the upper surface of the rod and reading the angle on the external scale of the clinometer. Leave the depth reading for the station blank but flag the measurement to indicate a non-standard procedure was used. Record the water level on the rod and the rod angle (vertical = 90°) in the comments section of the field form. When you return to the office, calculate the thalweg depth as the measured depth (length of rod that was under water) multiplied by the trigonometric *sine* of the rod angle. (For example, if 3 meters of the rod are under water when the rod was held at 30 degrees (*sine* = 0.5), the actual thalweg depth is 1.5 meters.) If a direct measurement cannot be obtained, make the best estimate you can of the thalweg depth and flag the data point to indicate that it is an estimated depth.

4. Proceed upstream to next station (determined by interval length) and repeat step 3 until all measurements are complete.

LARGE WOODY DEBRIS ESTIMATE

The large woody debris (LWD) estimate should **be performed concurrent with the thalweg profile** such that the recorder of the depth measurements also estimates the percent aerial coverage of woody material **within the bankfull channel.** This component of habitat characterization allows a semi-quantitative estimate of the number, volume, and distribution of wood within the total reach. LWD is defined as woody material with a small end diameter of at least 10 cm (4 in.) and a length of at least 1.5 m (5 ft).

The estimate includes all pieces throughout the entire reach that are at least partially within the bankfull channel (Zone 1 or 2 in **Figure 4**) or bridging above it (Zone 3 in **Figure 4**). The active (or bankfull) channel is defined as the channel that is filled by moderate-sized flood events that typically recur every one to two years. Pieces of LWD that are not at least partially in Zones 1, 2, or 3 are not counted. Record estimates on the **Large Woody Debris** section of the **Cross Section,**

Thalweg Profile, and Large Woody Debris Field Form.

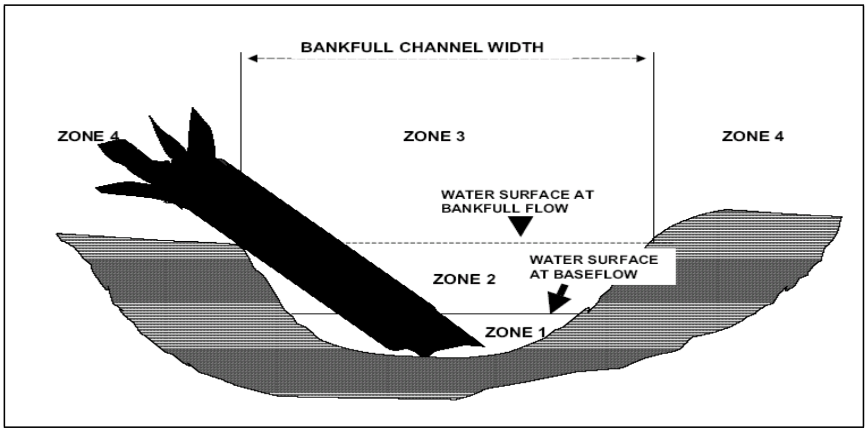

Figure 4. Large woody debris in bankfull channel

Procedure for Estimating Large Woody Debris

1. The LWD amounts are estimated between all lettered transects within the total reach (i.e., between A-B, B-C, C-D, and D-E).

2. Scan the stream segment (A-B, B-C, etc.) for LWD and estimate the amount of LWD that are at least partially within the bankfull channel or are at least partially bridging the bankfull channel (Zones 1, 2, and/or 3 in Figure 4).

3. Write 1 in the appropriate box (dense, abundant, common, rare, absent) in the Large Woody Debris section of the field form. Dense is defined as greater than 75% of the reach has LWD within or bridging the bankfull channel; Abundant signifies 40-75% of the reach has LWD; Common refers to 10-40% of the reach has LWD; and Rare indicates that less than 10% of the reach has LWD.

4. Repeat steps 2 and 3 for the next stream segment and record estimate on the field form.

6.3.3 Percent Canopy Cover

The amount of riparian vegetation intercepting solar radiation may be quantified as the average percent canopy density through the procedure outlined in this SOP.

Canopy cover over the stream is determined at each of the 5 lettered transects (Transects A – E). A convex, spherical densiometer is used (Lemmon 1957). Mark the densiometer with a permanent marker or tape exactly as shown in Figure **5** to limit the number of square grid intersections to 17. Densiometer readings can range from 0 (no canopy cover) to 17 (maximum canopy cover). Six measurements are obtained at each lettered transect (four measurements in each of the four directions at mid-channel and one at each bank as shown in Figure 5).

Densiometer measurements are taken at 0.3 m (1 ft) above the water surface, rather than at waist level, to (1) avoid errors because people differ in height; (2) avoid errors from standing in water of varying depths; and (3) include low overhanging vegetation more consistently in the estimates of cover. Hold the densiometer level (using the bubble level) 1 foot above the water surface with your face reflected just below the apex of the taped "V", as shown in Figure 5. Concentrate on the 17 points of grid intersection on the densiometer that lie within the taped "V". If the reflection of a tree, branch, or leaf overlies any of the intersection points, that particular intersection is counted as having cover. Any vegetation or overhanging bank covering the intersections is counted. For each of the six measurement points, record the number of intersection points (0 to 17) that have vegetation or bank covering them in the appropriate section of the **Percent Canopy Cover Field Form.** To calculate the measurements to percent canopy cover, the readings are summed and divided by the total possible points (Fitzpatrick, et al. 1998) and then multiplied by 100. The picture on the left depicted in Figure 5 would be recorded as a 10, which indicates that 10 intersections are covered on the modified densiometer. See canopy cover measurement procedure below.

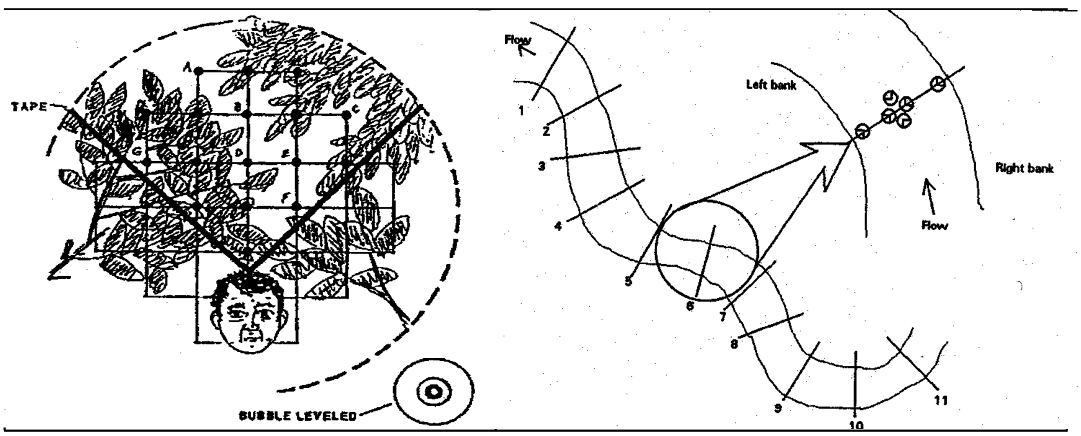

Figure 5. Proper use of densiometer and measurement locations within each transect (Mulvey et. al. 1992)

Procedure for Canopy Cover Measurements

1. At each lettered transect (Transects A – E), stand in the stream at mid- channel and face upstream.

2. Hold the densiometer 0.3 m (1 ft) above the surface of the stream. Level the densiometer using the bubble level. Move the densiometer in front of you so your face is just below the apex of the taped "V".

3. Count the number of grid intersection points within the "V" that are covered by either vegetation or bank material. Record the value (0 to 17) in the *CENUP* field of the canopy cover measurement section of the **Percent Canopy Cover Field Form**.

4. Face toward the left bank (left as you face downstream). Repeat Steps 2 and 3, recording the value in the *CENL* field of the field data form.

5. Repeat Steps 2 and 3 facing downstream, and again while facing the right bank (right as you look downstream). Record the values in the *CENDWN* and *CENR* fields of the field data form.

6. Move to the water's edge (either the left or right bank). Repeat steps 2 and 3 again, this time facing the bank. Record the value in the *LEW* or *REW* field of the field data form. Move to the opposite bank and repeat.

7. Repeat Steps 1 through 6 at each lettered transect (Transects A – E).
   NOTE: Side channels are included when determining measurement locations when established islands are present at lettered transects (Transect A-E).

6.3.3 Pebble Count

Substrate size is one of the most important determinants of habitat character for fish and macroinvertebrates in streams. The term substrate size is used to describe the size of streambed surface particles. Substrate size is evaluated at each of 21 equally- spaced transects (refer to Figure 1 and Table 2) using modified EMAP methods (Peck, et al. 2006). For a reach length of 160m, transects will be 8m apart. For longer reaches, the distance between intermediate transects is the reach length divided by 20. Distance between the transects can be determined using a measuring tape held between the downstream and upstream transect and should follow the stream channel. The basis of this protocol is a systematic selection of 5 substrate particles from each of the 21 transects. The substrate sampling points along the transects are located at 0, 25, 50, 75, and 100 percent of the measured wetted width, with the first and last points just inside (approximately 5 cm) of the water's edge (Figure 6).

If the channel is split by a predominately non-vegetated mid-channel bar, the five substrate points are still placed between the overall wetted width boundaries regardless of the mid-channel bar in between. Consequently, substrate particles measured in some portions of a transect may be above the current water surface. If there is a vegetated mid-channel bar that splits the channel into roughly two equal parts, measure three pebbles in one half and two in the other. If the majority of flow is to one side of a vegetated bar, measure all five pebbles in the dominant channel as described in the above paragraph. For transects that are entirely dry, make measurements across the unvegetated portion of the channel. Be sure to note the occurrence of dry mid-channel bars on the field form.

The procedure for obtaining substrate measurements (i.e., pebble count) is described below. Record measurements in the PEBBLE COUNT section of the Pebble Count Field Form. To minimize bias in selecting a substrate particle for size classification, it is important to concentrate on correct placement of your foot along the cross-section and to select the particle right off the tip of your big toe (not, for example, a more noticeable large particle that is just to the side of your foot). It is also important that bare hands are used, so that the subtle differences in FINES and SAND are observed.

When differentiating between SAND and FINES, follow these steps:

- If the selected point is possibly less than or equal to 2mm, pinch a small pea-sized amount of material and remove it from the stream.
- First confirm that the particles in the sample are less than or equal to 2mm.
- If less, rub the material between the forefinger and thumb. Any feeling of grittiness or the feeling of single grains rolling between your fingers indicates SAND.
- A slick or sticky feeling, or a lack of grittiness indicates FINES.

*__ANY feeling of grittiness should be recorded as SAND.__

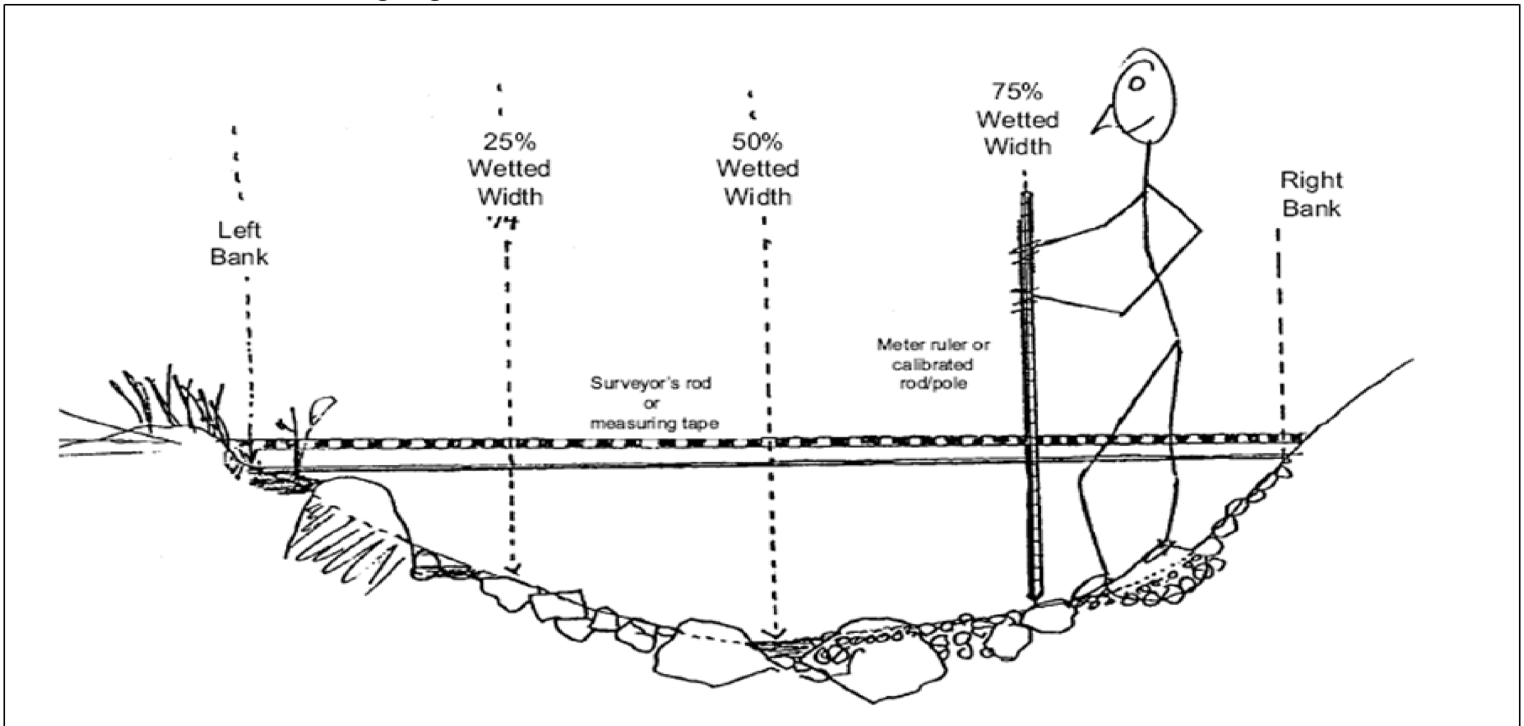

Figure 6. Substrate Sampling Cross-Section

PEBBLE COUNT PROCEDURE

1. Starting at the bottom of the reach (Transect A), divide the **WETTED WIDTH** channel by 4 to locate the substrate measurement points along the transect (Left Edge, 25%, 50%, 75%, and Right Edge), with the first and last points just inside (approximately 5 cm) of the water's edge).

2. Place your foot at each measurement point along the transect. Avert gaze (do not look down unless needed for safety), slide your index finger straight down off of your big toe, and pick up the first particle touched by the tip of your index finger. If a sand or fines

substrate layer is present but too thin to grab a pea-sized pinch, sample and record the underlying substrate. If the measurement point falls in a pool that is unsafe to sample, assume the substrate at the measurement point is sand unless it is clearly bedrock. Measure the intermediate axis with a metric ruler or measuring caliper (refer to **Figure 7**). If the particle is too large to pick up measure the intermediate axis under water with a ruler, surveyors rod, or measuring tape. Record the intermediate axis in millimeters (pebble width) in the PEBBLE COUNT section of the field form corresponding to the transect and location along transect (Left Edge, 25%, 50%, 75%, Right Edge).

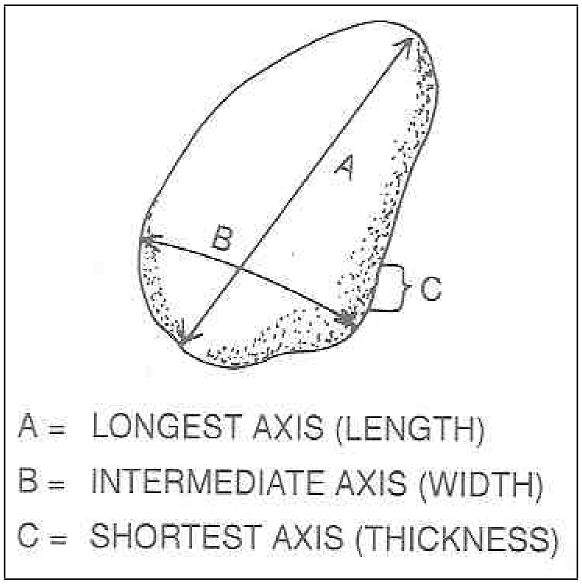

Figure 7. Substrate particle showing its 3 main axes of measurement. (Harrelson, et al. 1994).

3. Record particles that have an intermediate axis larger than 2mm as a whole number in the field sheet. “Gritty” particles with an intermediate axis less than 2mm are recorded as **SAND.** “Smooth” particles less than 2mm are recorded as **FINES.** Bedrock and consolidated substrates are recorded as **BEDROCK.** Streams with a calcified substrate cementing individual particles into a consolidated layer are also recorded as **BEDROCK.** If the particle encountered is not lithic in origin (i.e., wood, trash, etc.) move the sampling point to a new location in the transect.

4. Move successively to the next location along the transect. Repeat step 2 at each transect location.

5. Proceed upstream to the next intermediate transect (see Figure 1) and repeat steps 1-4. Substrate measurements will be collected starting at Transect A, all intermediate transects between Transects A-B, B-C, C-D and D-E. Substrate measurements will conclude at Transect E for a total of 105 individual pebble measurements.

6. Tally the total number of pebbles that are considered sand or fine sediment (i.e., particles less than or equal to 2 mm) and calculate the percent sand/fines by dividing the number of

sand/fine particles by the total number of particles (105), then multiply by 100.

6.3.4 Bankfull Cross Section with Stream Flow

Take stream flow (see **SOP 7.0**) and bankfull measurements in feet (ft) at a single, suitable location within the total reach to characterize geomorphology and flow conditions at the sampling point. The preferred location is at Transect C, but the location can be moved as necessary to find an area conducive to a stream flow measurement that is straight with perpendicular flow at the cross section. Data from this form are entered into WINXPRO and utilized during temperature TMDL development.

Follow the procedures in **Section 6.3.2** above to identify bankfull width and height. Record the left and right bankfull distances on the tag line on the flow form. Measure and record the bankfull height on the flow form. Take at least two measurements from the ground to the tag line (bankfull height, see Figure 8) in between the wetted edge and bankfull edge. Do this on both banks and record on the flow form. Record all flow measurements in cubic feet per second (cfs) and in tenth of feet (ft) and indicate which transect the flow was taken at. Follow **SOP 7.0** to collect a flow measurement.

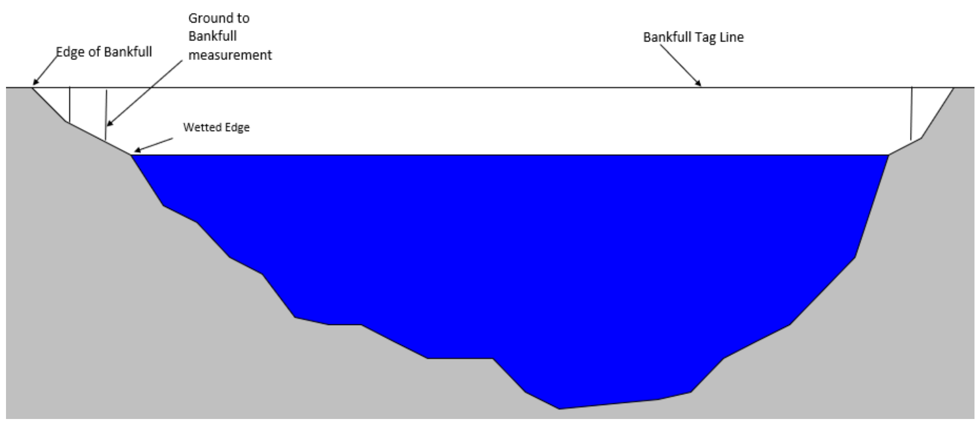

Figure 8. Bankfull and ground to bankfull tag line measurement

6.4 Photo-documentation

It is essential to take several photos of the reach condition and any disturbances or modifications that are relevant to data collection and assessment. Use a camera with GPS capabilities so that locations are collected with the metadata. Once back from the field, download photos into the project file (i.e., Specific Survey Folder on SWQB network).

7.0 Data Entry/Management

Enter all field form data into appropriate electronic Physical Habitat Forms (form can be found on the SWQB SOP website). Save these forms in the electronic project folder. Open the corresponding red worksheet (see **Figure 9**), copy the table, and paste the table into a blank excel workbook and save as csv file in the project file habitat folder. Each worksheet must be saved into its own .csv file for upload.

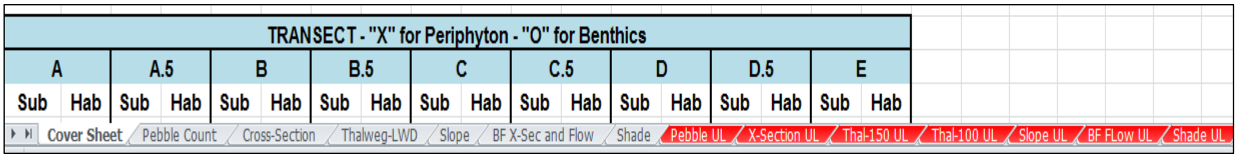

Figure 9. Example of worksheets requiring data entry. Red worksheets are used for upload.

7.1 SQUID GEOMORPH/HABITAT EVENT CREATION AND EXCEL DATA UPLOAD INSTRUCTIONS

7.1.1 CREATING A GEOMORPH/HABITAT EVENT WITHIN A STATION

1. Select the Project tab on the SQUID home page and select the appropriate project or use the Project Filter to search.
2. Select the View/Add Monitoring Location page.
3. Select the Sampling Events page for the specific station to which you are attaching Geomorph/Habitat data.
4. Under the *Add New Sampling Events* tab select *Geomorph/Habitat* under the *Sampling Event Type* drop down list and click *Add New Sampling Event* button
5. Under the General tab, populate the sampling event with the appropriate metadata:
    a. Start Date
    b. Field Staff
    c. Flow Method
    d. Comments
    e. Data Collected
    f. See Habitat and Biota Field Work Cover Sheet
    g. Latitude and Longitude
    h. Average Wetted Width
    i. Total Reach Length
    j. Interval Length
6. When metadata entry is complete select Save.

7.1.2 UPLOADING AN EXCEL DATA FILE TO THE SAMPLING EVENT

1. For each station open the *Sampling Event* page, under the *Type* column, go to the *Geomorph/Habitat* row for the monitoring date and time and select appropriate upload tab.
2. Select Browse within the filename window and navigate to the appropriate Geomorph/Habitat .csv file.
3. Select Upload File.

7.1.3 VIEWING UPLOADED DATA IN EXCEL

1. Select *Adhoc Report*,
2. Select *Project and Station*.
3. From the *Reports* sections select the *Geomorph/Habitat*.
4. Then Select Raw Data Report.

8.0 QA/QC

The SWQB controls the quality of the physical habitat field data by using standardized methods that are documented in this SOP. All personnel who collect physical habitat data must be familiar with these protocols, sign the acknowledgment form associated with this specific SOP and collect data in accordance with the procedures as they are defined in this SOP. In addition to standardized methods, proper training of field personnel represents a critical aspect of meeting the data quality objectives to fulfill the goals of the SWQB's QAPP (NMED/SWQB, 2024).

The SWQB implements QA/QC through initial and annual refresher training of the procedures detailed in this SOP for physical habitat surveys. SWQB staff, cooperators, and organizations who conduct physical habitat surveys with the intent of effectiveness monitoring of restoration projects or submitting the data for CWA 303(d)/305(b) Integrated Report consideration are required to receive training in the field by qualified MASS monitoring staff (or approval from MASS Program Manager) for all aspects of the habitat data collections. The MASS monitoring staff who conduct training in the field must have completed at least one full field season of physical habitat data collection before training other staff. Trained persons may conduct unsupervised habitat data collections once field training has occurred and all aspects of habitat data collections have been observed as correct. The training will be documented by Monitoring Team Supervisor and trainee will be approved for physical habitat data collection until next SOP revision. This process will ensure comparability and accuracy of data used for water quality assessments, refinement of water quality standards and TMDL development. The training of staff will reduce systematic bias of measurements identified in the procedures of this SOP.

Assurance of field data collection for physical habitat measurements are done through adherence to the process outlined in this SOP and oversight of the process by the QAO. If at any time the QAO determines this process is not being adhered to, the QAO has the authority to cease activities specific to this SOP with prior support and approval by the SWQB Bureau Chief and MASS Program Manager, until such a time that the issue can be resolved.

9.0 Related Forms

- Field Equipment Checklist Habitat
- SOP and/or quick reference guides for physical habitat

Field Forms:

- Habitat and Biota Field Work Cover Sheet
- Pebble Count Field Form
- Cross Section, Thalweg Profile, and Large Woody Debris Form
- Bankfull Cross Section and Stream Flow Field Form
- Slope Field Form
- Percent Canopy Cover Field Form

10.0 Revision History

Revision 1. March 23, 2011 – Minor edits and clarification of language.

Revision 2. August 8, 2012 – Updated references. Updated SQUID upload procedures. Clarified pebble count, flow, slope, thalweg, and logistics protocols. Scouring event defined. Field forms clarified.

Revision 3. September 21, 2014 – Updated index period guidelines.
Jodey Kougioulis, QAO; Scott Murray, SME; Jeff Scarano, Program Manager

Revision 4. April 15, 2016 – Added quality control, data entry/management, SQUID geomorph/habitat event creation and excel upload instructions and general formatting.
Vacant, QAO; Seva Joseph, SME; Shelly Lemon, Program Manager

Revision 5. June 26, 2019 – The biological monitoring period has been extended to provide flexibility for sampling. Details were added to the Step-by-step Process Description section to provide precision to survey procedures for repeatability. The QA/QC section was updated with a new procedure for additional quality control for physical habitat measurements. Minor editorial changes; grammar, formatting and clarity throughout SOP.
Miguel Montoya, QAO; Chuck Dentino, SME; Kristopher Barrios, Program Manager

Revision 6. September 17, 2019 – Additional language was added to SOP which clarifies data collection by observer for different surveys and the pebble count data collection procedure. The QA/QC section was also revised and included updates to pebble count replicate procedure and training requirements for physical habitat data collection. Minor grammatical editorial changes.
Miguel Montoya, QAO; Chuck Dentino, SME; Kristopher Barrios, Program Manager

Revision 7. June 9, 2023 – Clarified many terms in Table 2 and related field sheets to better match SQUID database terminology and intent of measurement(s). Removed definition and identification of an individual subject matter expert because there is no need to identify one in this particular SOP and all MASS Monitoring Team staff are considered and expected to be surface water quality monitoring subject matter experts.
Miguel Montoya, QAO; Lynette Guevara, Program Manager

Revision 8. November 20, 2025 – Updated Workflow data collection steps. Added the utilization of a laser range finder with slope measurement capabilities. Added/clarified training requirements. Removed requirement for pebble count field replicate.
Emily Miller, QAO; Lynette Guevara, Program Manager

11.0 References

Biggs, B. and C. Kilroy. 2000. *Stream Periphyton Monitoring Manual.* NIWA Christchurch, New Zealand.

Fitzpatrick, Faith A., Ian R. Waite, Patricia J. D'Arconte, Micheal R. Meador, Molly A. Maupin, and Martin E Gurtz. 1998. *Revised Methods for Characterizing Stream Habitat in the National Water-Quality Assessment Program*. U.S. Geological Survey Water-Resources Investigations

Report 98-4052. Raleigh, NC. Available at http://water.usgs.gov/nawqa/protocols/WRI98-4052/wri98-4052.pdf

Harrelson, C.C., C.L. Rawlins and J.P. Potyondy. 1994. *Stream Channel Reference Sites: an Illustrated Guide to Field Technique.* General Technical Report RM-245. Rocky Mountain Forest and Range Experimental Station. U.S. Forest Service U.S. Department of Agriculture. Fort Collins, CO.

Kaufmann, P.R., P. Levine, E.G. Robison, C. Seelinger, and D.V. Peck. 1999. *Quantifying Physical Habitat in Wadeable Streams*. EPA 620/R-99/003. U.S. Environmental Protection Agency, Washington D.C.

LaPerriere, J.D. and D.C. Martin. 1986. Simplified method of measuring stream slope. Cold Regions Hydrology Symposium, pp. 143-145, American Water Resources Association.

Lemmon, P.E. 1957. A new instrument for measuring forest overstory density. *Journal of Forestry* 55(9):667-669.

Mulvey, M., L. Caton, and R. Hafele. 1992. *Oregon Nonpoint Source Monitoring Protocols Stream Bioassessment Field Manual for Macroinvertebrates and Habitat Assessment.* Oregon Department of Environmental Quality, Laboratory Biomonitoring Section. 1712 S.W. 11th Ave. Portland, Oregon, 97201. 40 p.

New Mexico Environment Department (NMED/SWQB). 2025. Comprehensive Assessment and Listing Methodology. Available at: https://www.env.nm.gov/surface-water-quality/calm/

New Mexico Environment Department (NMED/SWQB). 2011. Development of Sedimentation /Siltation Impairment Thresholds in New Mexico. March 15, 2011. Available at: https://www.env.nm.gov/surface-water-quality/sedimentation/

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D.J. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M. Cappaert. 2006. *Environmental Monitoring and Assessment Program -Surface Waters Western Pilot Study: Field Operation Manual for Wadeable Streams.* EPA/620/R-06/003. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

Robison, P.E. and P.R. Kaufmann. 1994. Evaluating two objective techniques to define pools in small streams. Pages 659-668 in R.A. Marston and V.A. Hasfurther (editors). *Effects of human induced changes on hydrologic systems*. Summer Symposium proceedings, American Water Resources Association, June 26-29, 1994, Jackson Hole, Wyoming.

Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology. Pagosa Springs, CO.

Water Environment Research Foundation (WERF). 2007. Evaluating waterbody assessment and listing processes: Integration of monitoring and evaluative techniques. Alexandria.